Carbon Accounting and Sustainable Designs in Product Lifecycle Management

Prof. Deepu Philip

Department of Management Sciences

Dr. Amandeep Singh Oberoi

Imagineering Laboratory

Dr. Prabal Pratap Singh

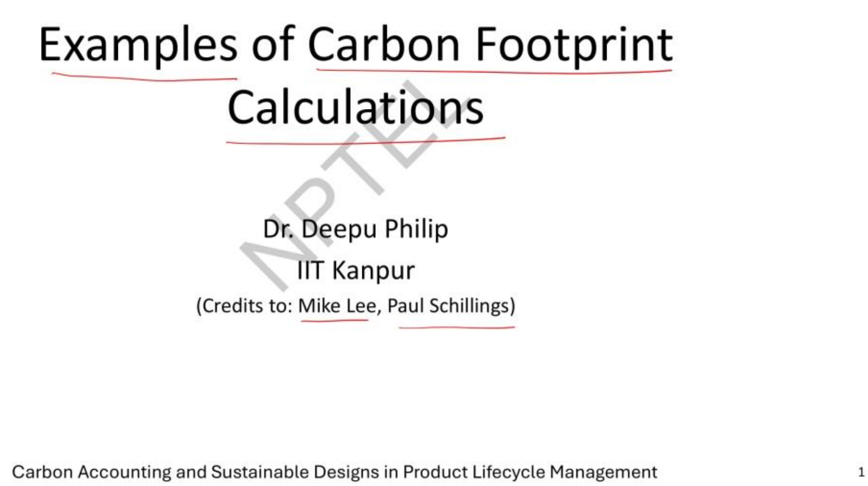
Department of Management Sciences

Indian Institute of Technology, Kanpur

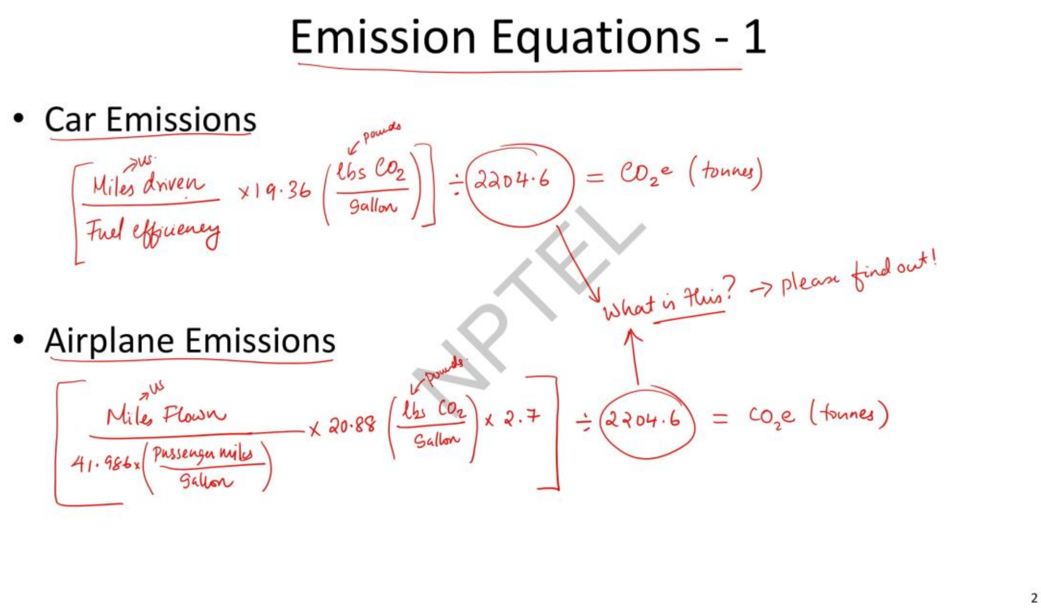
Lecture10

Examples of Carbon Footprint Calculations

Good afternoon, everyone. Welcome to yet another lecture of the course and NPTEL MOOCs titled Carbon Accounting and Sustainable Design in Product Lifecycle Management. And this course is offered from IIT Kanpur. And my name is Dr. Deepa Philip. And along with me, Dr. Amandeep Singh Oberoi and Dr. Prabhal Pradap Singh are also co-instructing this course.



And as we have seen in the previous sections and all, and we are talking about carbon footprint and etc., today we are going to talk about the examples of or how do we do carbon footprint calculations, okay? And this was in the previous lecture and now this is in a continuation of that, okay? And also, we would like to acknowledge Mike Lee and also Dr. Paul Schillings, both of them, who were my teachers. And I took classes from them. And some of these concepts actually came from them.



So let's first talk about the fundamental Emission Equations. These emission equations are very popular and people use it. And let's take two examples. I am not going to go through every emissions. Just talk about car emissions and airplane emissions.

So the car emissions equation is given by

$$\left[\frac{Miles\ Driven}{Fuel\ Efficiency} \times 19.36\ \left(\frac{lbs\ CO_2}{gallon}\right)\right] \div 2204.6 = CO_2e\ (tonnes)$$

Remember most of these were created in United States. So you will find most of them in the US units.

Now, for airplane emissions,

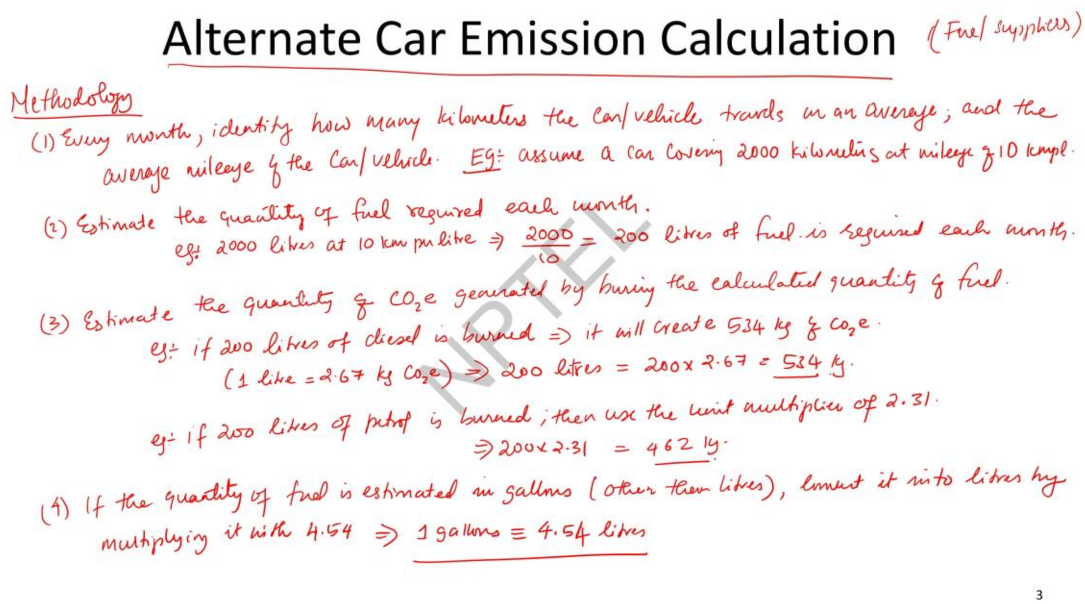
$$\left[\frac{Miles\ Flown}{41.986 \times \frac{Passenger\ miles}{gallon}} \times 20.88\ \left(\frac{lbs\ CO_2}{gallon}\right) \times 2.7\right] \div 2204.6 = CO_2e$$

Here also, this will be in US units (miles). In this case, the previous case, it was, you can think about it as petrol or gasoline.

In this case, it is actually aviation fuel multiplied by 2.7. This much is the whole calculation for airplane divided by 2204.6, which is equivalent to your CO2e. That's in tons. So, one thing that you can see is there is something that is common. Okay.

The question is, what is this? Okay. So, please find out. you have to go around, search and find out what does that represent. So, I hope you guys understand the carbon emissions.

So, in the car emissions, the equation I am going over it again, miles driven divided by fuel efficiency multiplied by 19.36, that is pounds of carbon dioxide per gallon of fuel divided by 2204.6 gives you the carbon dioxide equivalent in tons for car emissions. For airplane emissions, it is the miles flown by the aircraft divided by 41.986 passenger miles per gallon multiplied by 20.88 pounds of carbon dioxide per gallon of aviation fuel. So, this is again pounds of aviation fuel multiplied by 2.7 divided by 2204.6 will give you the carbon dioxide equivalents. Now, there is an alternate way. This is one option is mug up the equation.



Another way of doing it is, you can also have an alternative way of calculating this. And this is usually done by many of the fuel suppliers. So, like Exxon Mobil and all, they use this model. So, the methodology. How do you do that?

So, number one, first step. Every month, identify how many kilometers the car or vehicle travels on an average. So, it's like, for example, average and the average mileage, mileage of the car or vehicle. So, example, example, assume a car covering 2000 kilometers at mileage of 10 kilometers per liter.

Assume it that way. That is the case. Then estimate the quantity of fuel required each month. So, example, 2000 liters at 10 Km per liter equal Implies $\frac{2000}{10}$ will give you 200 liters of fuel is required each month. Now, the estimate the quantity of carbon dioxide equivalent generated by burning the calculated quantity of fuel.

So, example here. If 200 liters of diesel is is burnt. Assume that the car is like Toyota Innova. Then burnt, it will create 534 kilograms of CO_2e. Where did I get this 532 kilograms?

That is 1 liter of diesel is equal to 2.67. kilograms of CO_2e. So, $200\, liters = 200 \times 2.67 = 534$. That is how you calculate that. Now, example, if 200 liters of petrol is burnt, Instead of diesel, let us say it is 200 petrol.

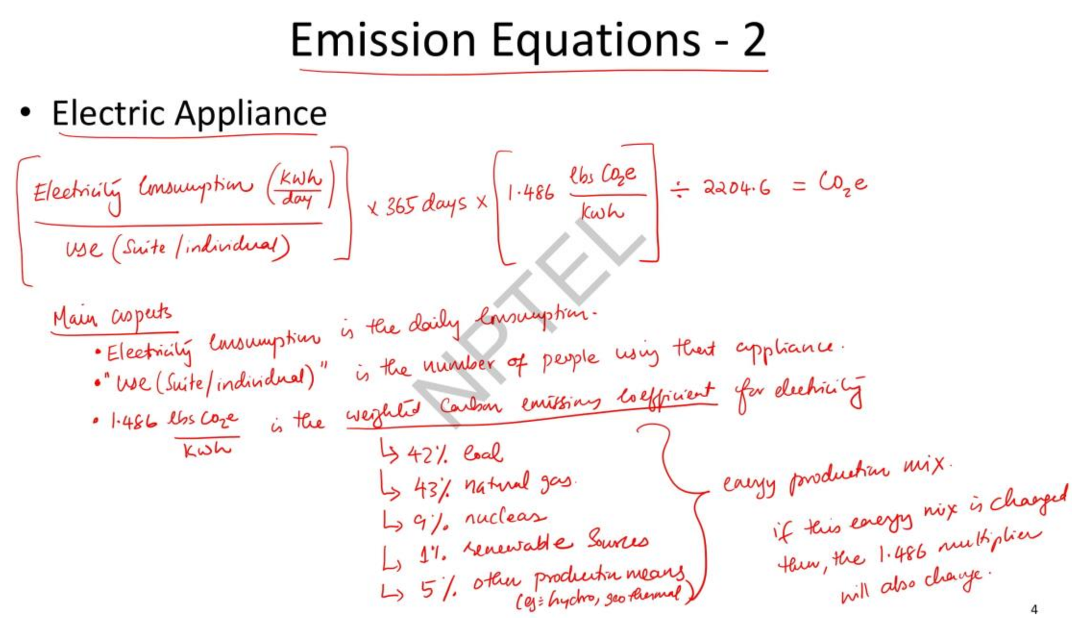
Then, use the unit multiplier of 2.31. So, it is, it implies $200 \times 2.31 = 462\ kg$

So, that is the amount of carbon dioxide that will be emitted out.

Now, one more thing. If the quantity of fuel is estimated in gallons, okay, that's other than liters, liters, then convert it into liters by multiplying it with 4.54, which implies

$$1\ gallon \equiv 4.54\ litres$$

So, if you are getting it in gallons, all these calculations, estimations are for liters, not for gallons. If you are estimating it in the form of gallons or US gallons, then this is 4.54 liters per gallon. That is the one that you will use to estimate it. So, this is an alternate way of actually calculating it.



Now, let us also talk about one more emission equation, second set of emission equation, which is explicitly meant for an electric appliance.

So, the electric appliance emission equation, it is given by

$$\left[\frac{Elecricity\ Consumption\ \left(\frac{KWh}{day}\right)}{Use\ \left(\frac{Suite}{Indivisual}\right)}\right] \times 365\ days \times \left[1.486\ \frac{lbs\ CO_2e}{KWh}\right] \div 2204.6 = CO_2e$$

So, there are some aspects in this that we need to figure out. So, the main things are main aspects. Main aspects are number one, electricity consumption electricity consumption is the daily consumption. The daily consumption. How many kilowatt hours per day?

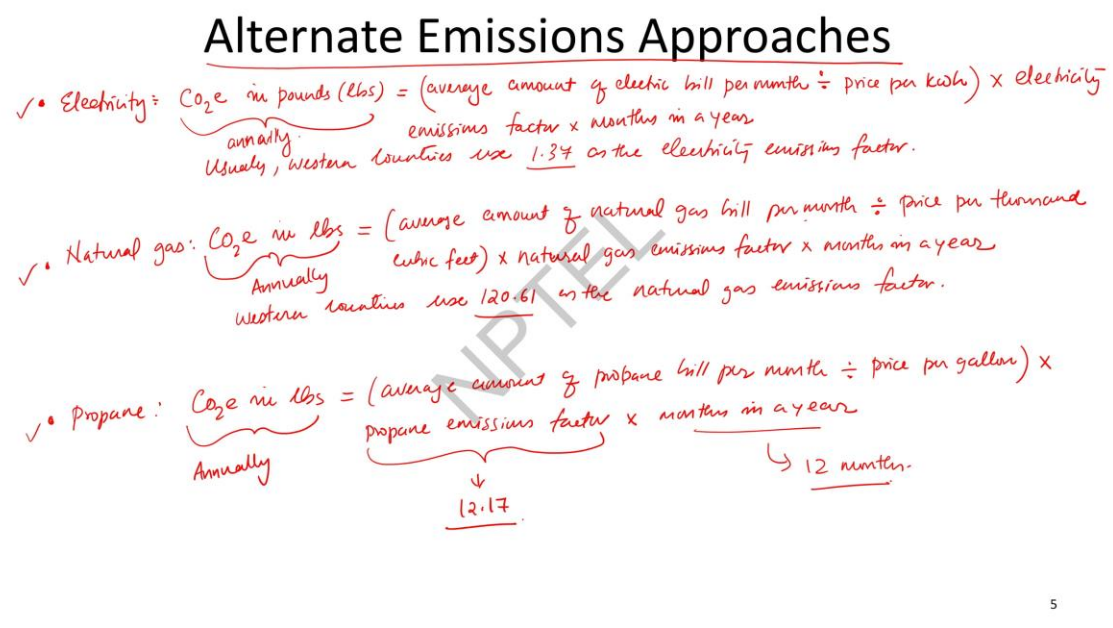
That is the first part. The second one is use of suit individual. Okay. That aspect is the number of people number of people using that appliance.

Then comes is the 1.486 lbs CO_2e per kWh kilowatt hour is the weighted carbon emissions coefficient for electricity. Okay. So this is the weighted carbon emissions coefficient. How is this weight calculated?

It is calculated by 42% coal. Then the second one is 43% natural gas 9% nuclear, 1% renewable, and 5% other production means, which includes hydroelectricity and other things. Okay, this is the energy production mix. We assume that 42% is from the burning coal, 43% is from the natural gas, 9% is from nuclear, 1% is renewable sources.

Okay, and 5% of other production means like example will be hydroelectricity, hydro, geothermal, etc., These are all examples of this. So, if this energy mix is changed, if we change this energy mix, then the multiplier, the 1.486 multiplier will also change. So, this is the American standard that we are talking about. But the logic here is that the philosophy or the equation remains the same or if India is using 80% call only.

So, then this multiplier 1.486 need to be changed to what the new multiplier is. So, this is another way of actually calculating the electric appliance emissions.



So let us take a simple example okay Alternate Emission Approaches a simple example of an electric electric appliance where we use electricity so let us take a one is electricity, okay.

$$CO_2\ in\ pounds\ (lbs) = Average\ amount\ of\ electric\ bill\ per\ month \div price\ per\ KWh \times electricity\ emission\ factor \times months\ in\ a\ year$$

So, usually, Western countries use 1.37 as the electricity emissions factor, okay. So, this is the usual thing that we do in this.

Now, let us take instead of electricity, let us take natural gas.

$$CO_2\ in\ lbs = (average\ amount\ of\ natural\ gas\ bill\ per\ month \div price\ per\ thousand\ cubic\ feet) \times natural\ gas\ emission\ factor \times months\ in\ a\ year$$

Western countries use 120.61 as the natural gas emissions factor factor. so you multiply it by how many months in a year and you use the factor 120.61 whereas in the electricity it is 1.31, 1.37.

And let us talk about propane, which is a very popular gas in Western countries, including US, Japan and all.

$$CO_2\ in\ lbs = (average\ amount\ of\ propane\ bill\ per\ month \div price\ per\ gallon) \times propaneemission\ factor \times months\ in\ a\ year$$

In a year and the propane emissions factor in this case, okay, that is 12.17. So here is an example of using three things electricity an alternate way of looking at electricity or natural gas or propane. So how can we calculate the carbon dioxide equivalents or CO_2. So these are all again you can imagine annually per year, okay. This is also annually. So, these are all annual estimations because you have seen the months per year.

And this is always 12 months in any year. So, all these cases, this is months is 12. You keep on multiplying with 12 so that you get the annual quantity. So, I think this will be a good point for us to stop today because there is a lot of equations that you need to learn and understand. I suggest that you guys understand the equations, take data from internet or something, work on this and understand how you can calculate this.

And go from there and then we will be doing more emission calculations in the next class based on other things and then we will continue from there on some different calculations and different factors for the globally known aspects. So thank you very much for your patient hearing good luck and I'll see you in another week.

Thank you.